Spinning Quality of Cotton Harvested With Three Types of Spindle Pickers and by Hand in California

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PREFACE

Although unusual delay occurred in getting the test samples spun and analyzed for this report, the results of this test are still valid and of benefit to cotton producers. The three types of picker spindles are still in use or commercially available.

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SUMMARY AND CONCLUSIONS

Studies were conducted in the San Joaquin Valley of California in 1961, 1962, and 1963 to evaluate the effects of hand picking and of three types of picker spindles used in mechanical harvesting on the quality and spinning performance of cotton. Mechanical harvesters were equipped with ¼-inch straight barbed, 3/16-inch straight smooth, and 3/16-inch tapered barbed spindles.

The seed cotton for the study was harvested from normally farmed fields of Acala 4-42 variety cotton. Enough seed cotton was harvested from randomized areas within the field to provide lint for four 300-pound replications. The cotton from each of the four harvesting methods was ginned in a typical commercial gin with moderate overhead cleaning and two stages of lint cleaning.

The seed cotton arriving at the gin showed only minor or no differences among methods of harvesting in appearance, trash, or moisture content, except the hand-picked cotton had a significantly lower moisture content in 1961 and 1962 and a significantly lower trash content in 1963 than did all machine-harvested cotton.

The test bales were sampled for fiber evaluation and spun for analysis of processing performance and yarn quality by the Market Quality Research Division, Clemson, S. C. Comparisons of the measured characteristics of fiber and yarn fell logically into three categories: (1) Characters exhibiting no differences among harvesting methods, (2) characters indicating a difference between hand-picked cotton and machine-picked cotton, and (3) characters indicating that cotton picked with barbed spindles was different from that picked with smooth spindles or that picked by hand.

After spinning, no difference could be detected in the yarn appearance or yarn irregularities among the four harvesting procedures. Differences in fiber length, length uniformity, strength, and fineness among harvesting methods were not significant at the 5-percent level.

Hand-picked cotton was judged by the U.S.-D.A. Cotton Classing Office, Bakersfield, Calif., to be one-half to one grade better than all machine-picked cotton. Hand-picked cotton also exhibited lower trash content with lower picker and card waste and less ends-down during spinning. The yarn strength of hand-picked cotton was slightly less than that of mechanically picked cotton. The averages for the mean fiber length and the long-fiber content were slightly lower and the coefficients of variability of fiber length and the short-fiber content slightly higher for hand-picked cotton. Although these values could not be shown to be different at the 5-percent level, small differences in fiber properties have been shown to accumulate and materially affect yarn strength.

The cotton picked with both types of barbed spindles produced a greater number of ends-

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down at spinning and a greater number of neps in yarn than that picked by hand or with the smooth spindle at the 10-percent level of significance. At the 5-percent level of significance, only cotton picked with the tapered barbed spindle had more than that picked with the straight smooth spindle.

The differences in spinning performance and yarn quality of cotton picked by the three types of spindles used in this study are of doubtful economic importance. Other considerations, such as durability, convenience, and field operation, are probably more important than these differences in lint and yarn quality and spinning performance. In some respects, the lint from hand-picked cotton may be superior to machine-picked cotton. However, since the greatest differences were related to nonlint content, the economic importance of the differences shown in this test would be minimized with the addition of crusher rolls in mills.

INTRODUCTION

Before 1950 only a small fraction of the cotton crop was mechanically harvested, but in 1969 it was estimated that 96 percent of the production of the United States was mechanically harvested, with several States approaching 100 percent. As the volume of hand-picked cotton decreased, the quality of workmanship deteriorated so that at present hand laborers gather more stems, burs, partially opened bolls, green leaf, and other foreign matter than ever before. As the volume of mechanically harvested cotton increased, improved cultural and harvesting techniques were developed and mechanical improvements were incorporated in the equipment so that now mechanically harvested cotton is rapidly becoming the industry standard.

This accelerating revolution has created many changes in a cotton economy based on a relatively uniform hand-picked crop. During the period since 1950 much research has been devoted to maintaining the existing quality of the finished cotton product and to increasing the overall efficiency of production. Early research was primarily concerned with mechanical efficiency as affected by production methods and harvesting and ginning machine designs. Cotton quality was measured primarily by grade and staple. Later research has been concerned with all factors that influence the quality of the finished cotton product. These later studies have been made by research personnel from production, harvesting, ginning, and mill projects to form a research team that could investigate the interaction involved throughout the cotton industry.

Before 1960 all cotton in harvesting-quality tests that was evaluated through pilot spinning was picked with the same type of spindle machine. No quality comparisons among spindle types or other spindles to hand-picked cotton were available. Therefore, 3-year studies were begun in Mississippi in 1960 and in California in 1961 to obtain information on the effect of various spindles on cotton quality. This report summarizes the results of California tests. Results of the Mississippi study are available in U.S. Department of Agriculture, Marketing Research Report No. 730, "Comparative Effects of Mechanical Picking Spindles and Handpicking on Cotton Quality and Spinning Performance in Mississippi 1960–63."

The objective of the California picker-spindle study was to determine, by pilot spinning plant tests, the effect on spinning quality of harvesting cotton with tapered barbed spindles, straight barbed spindles, straight smooth spindles and by hand. The objective was limited to the effect of spindles on fiber quality; comparisons of machine performance or overall harvesting efficiency were not included.

GENERAL PROCEDURES

Equipment

Cotton-harvesting machines of the same age were used for the 3-year comparison of spindles. The same tapered-spindled machine, which was new before the 1961 harvest, was used all 3 years. The same spindles were used in 1961 and 1962. Before 1963 season, 50 percent of the spindles were replaced. The same two 1961

model straight-spindled machines were used in 1961 and 1962. Different 1961 model straight-spindled machines were used in 1963. All straight-spindled machines were factory equipped with smooth spindles; therefore, each year before the test period a set of straight barbed spindles were placed in one of the machines selected at random.

The machines were adjusted and operated according to manufacturer's recommendations. The compressor sheets were adjusted with low pressure and minimum spindle clearance for high-quality harvest. The same spindle moistening agent at the same concentration was used in all machines in all years. The flow rate was adjusted to the minimum that would maintain efficient harvest and spindle cleanliness (appendix table 1). At least one bale of cotton was harvested by each machine before the plots were harvested to minimize oil and trash contamination.

Harvest conditions and procedure

Early-maturing fields were selected each year in the Arvin area. Solid-planted fields were used in 1961 and 1962. A skip-row field—two planted rows and two skipped rows—was used in 1963. The plant heights varied from 38 inches to 43 inches and populations, from 66,000 to 29,000 plants per acre (appendix table 2). The yields varied from 1½ to 2½ bales per acre.

The fields were defoliated with a magnesium chlorate defoliant at a rate of 5 pounds per acre 10 to 20 days before harvesting. Fields were divided into plots large enough to provide 300 pounds of lint, and the harvesting treatments were randomized within replication blocks.

The hand harvesting was started early on the morning of the test day and extended into late afternoon. It was necessary to return the following day for 3 hours to complete the hand harvest in 1961. The machine harvesting required only 2 to 3 hours to complete and was done during the period of lowest relative humidity for the test day. The relative humidity was 40 percent in 1961, 35 percent in 1962, and 70 percent in 1963. The weather was foggy in 1961 and 1963, but in 1961 the fog cleared and the relative humidity dropped.

The harvested lots were placed in separate compartments in wagons and transported to the gin. The ginning was done the day after harvesting in 1961 and the same day as harvesting in 1962 and 1963.

Ginning

The objectives of these tests required that the cotton be ginned alike and that good ginning practices be used. A typical commercial gin [4] having machinery arrangements consistent with good ginning practices for machine-harvested cotton was selected. This gin was equipped with two driers; 19 cylinders of cleaning; stick machine; and two stages of lint cleaning (fig. 1). Unforseen circumstances necessitated that the 1963 cotton be ginned at another gin.[5] This gin, however, was almost identical in machinery arrangement with the other gin, and the change has no effect on the test results.

The gins were operated under normal conditions and normal ginning practices were used except for rate of feed. Even though ginning capacity was not a factor, it was important that none of the cotton went into the overflow and did not go back to the overhead cleaning equipment. Therefore, the rate of feed was adjusted so that only four gin stands were usually kept in operation, and the last stand was used to gin the cotton that normally would have been in the overflow.

Normal weather conditions prevailed all 3 years during harvest. Gin-room temperatures, relative humidity, and time of day during tests were recorded. In 1961 on September 27, between 2:00 and 4:00 p.m. the temperature was 94° F. and the relative humidity was 20 percent. In 1962 on October 6, from 10:00 a.m. to 1:00 p.m. it was 81° and the relative humidity was 37 percent. In 1963 on October 23, from 5:00 to 7:00 p.m. the temperature was 63° and the relative humidity was 75 percent.

The cotton was received from the field in a dry condition and no artificial heat was used in the driers, but because of several changes of ambient air in the ginning system some slight moisture removal resulted. In 1961 and 1962 seed-cotton moisture in the trailers was approximately 6 and 7 percent, respectively. In

[4] Arvin Cooperative Gin, Arvin, Calif.
[5] Weedpatch Ginning Company, Weedpatch, Calif.

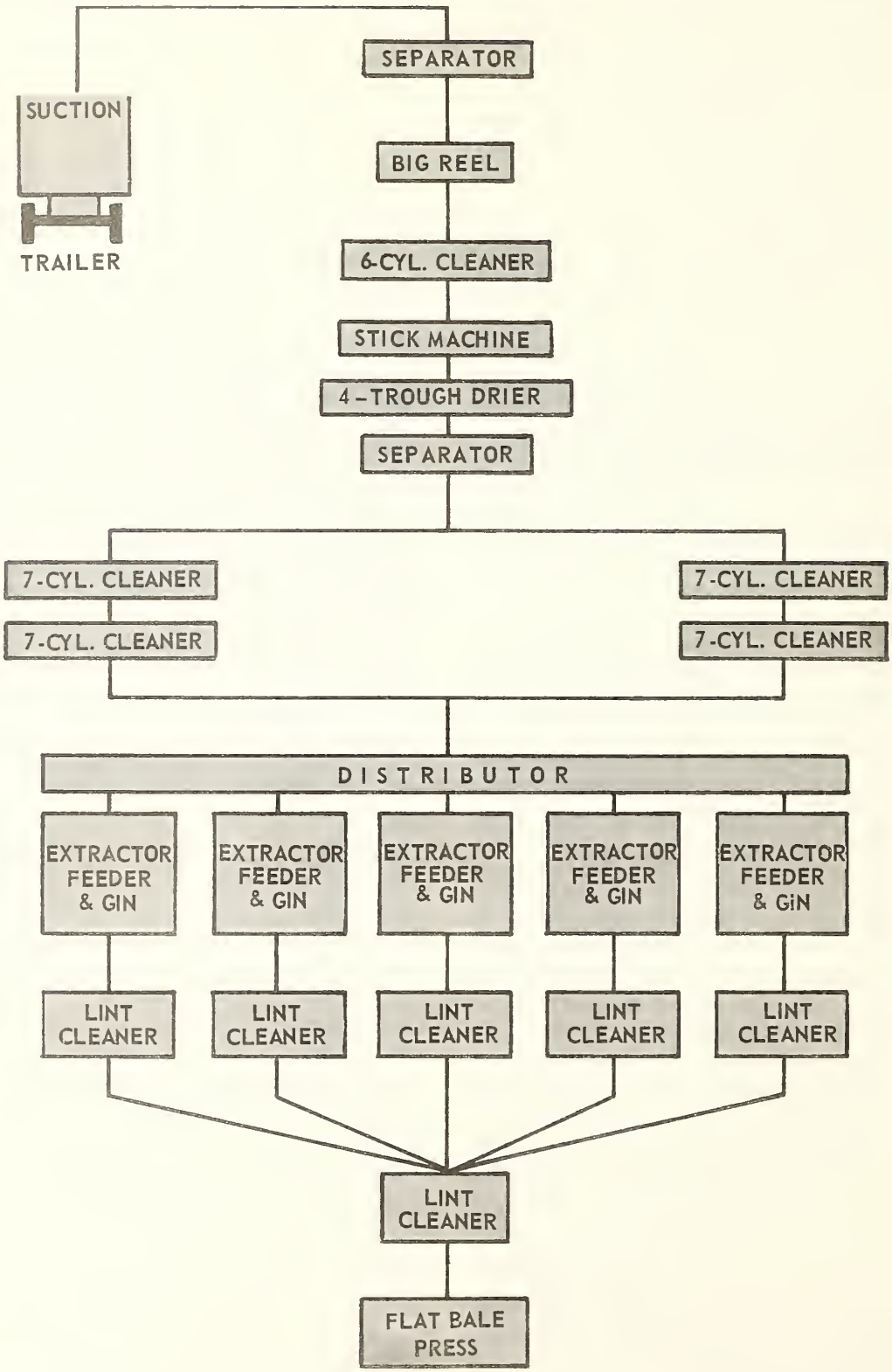

Figure 1.—Flow of cotton through gin, California, 1961–63.

1963 it was considerably higher (13 percent). Since no heat was used in the driers in previous years, none was used in 1963 because this would have introduced an objectionable variable of drying in the test results. The high moisture content of the 1963 cotton could account for the large number of rib tags that occurred during the ginning of the test cotton.

CONDITION OF SEED COTTON

The amount of foreign matter contained in seed cotton harvested by the three types of spindles was about equal and uniformly low for each of the 3 years (appendix table 3). Moisture in incoming seed cotton was also uniformly low for the three spindles except in 1963 when more than normal rainfall occurred before harvest. Seed-cotton drying was not used on any of the test cottons. For any year there were no differences in moisture content of the ginned lint among the harvesting methods. The level of lint moisture at the lint-slide content for 1963 was about 1½ percentage points higher than that for the other 2 years.

FIBER QUALITY

Grade and staple

On the average, grades from hand-picked cotton are usually better than those from machine-harvested cotton. Although foreign-matter determinations indicate that trash may be present in equal amounts, the kind of trash in seed cotton picked by hand is more easily removed by cleaning machinery than that in machine-harvested cotton.

In these tests, hand-picked cotton averaged one-half to one grade better than machine-harvested cotton (appendix table 4). The type of spindle used in mechanical harvesting had no significant effect on grade levels.

Staple length was slightly lower for hand-picked cotton; but, again, the type of spindle used had no discernible effect on staple length as measured by the cotton classers.

Fiber length

Fiber length was measured by mechanical sorting (Suter-Webb array) and by electronic scanning (Fibrograph).

During each of the 3 years there was no difference in fiber length among the three types of spindles tested (appendix table 5), as measured by the array method. In addition, cotton harvested by hand had similar length characteristics.

Mean length (determined by the array method) is a weighted average length of the fibers examined and gives greater emphasis to the amount of long fibers present. Although the 1961 tests indicated that hand-picked cotton and that harvested with the ¼-inch straight barbed spindle had a slightly lower mean length, the 3-year averages indicate that this difference (appendix table 6) is small and of no importance.

Coefficient of variation as measured by the array method indicated that hand-picked cotton was only slightly more variable in length than was cotton harvested mechanically (appendix table 7). Normally, mechanical harvesters are more selective in the picking process, but in these tests all fields were well opened before picking. The 3-year means indicate that there was no significant difference in variability among the harvesting methods.

This degree of similarity is substantiated by the percentage of fibers shorter than ½ inch (by weight) as calculated from the array method (appendix table 8). No differences existed for any of the 3 years among the harvesting methods or for the 3-year averages for them.

The type of spindle used had no effect on the percentage of fibers longer than 1 inch (appendix table 9). At the 10-percent significance level, hand-picked cotton had slightly less long fibers than that harvested with the 9/16-inch tapered spindle for the 3-year averages; but this difference was not apparent at the 5-percent level.

It appears that from a practical standpoint there are no differences in length and length-distribution measurements that can be attributed to the use of any specific type of picker spindle. In addition, the study indicates that, for this western area, the condition of the fields

at picking time is such that there is very little or no difference between hand-picking and mechanical harvesting in their effect on these quality measurements.

Results of tests made by the Fibrograph are not indicated in this report, since these results differed even less than those by the array method.

Fiber strength

Strength of fibers was measured by the Pressley strength test. Two gages were used—the zero gage and the 1/8-inch gage. Results obtained by the zero gage are expressed in thousand pounds per square inch and those by the 1/8-inch gage are expressed in grams per tex.

In 1961, cotton harvested with the 3/16-inch straight smooth spindle produced stronger cotton than the other harvesting methods when measured by the 1/8-inch-gage test (appendix table 10); the zero-gage tests for this year indicated no differences due to harvesting method. In 1962, the results were reversed for the test methods; in 1963, there were no differences. The 3-year averages indicate that at the 5-percent significance level there were no differences. At the 10-percent level, significant differences in favor of the 3/16-inch tapered barbed and 3/16-inch straight smooth spindle existed. However, these differences were small; hence, no practical importance can be attached to them.

Fiber fineness

Fineness of the cotton fiber should not be affected by method of harvesting, unless climatic conditions cause characteristics to vary widely. Normally, mechanical harvesters are selective in that the spindles pick only the open and fluffed locks from the boll.

Hand pickers normally harvest other than fully matured cotton. Under normal western arid conditions, the incidence of boll rot is negligible and harvesting is performed when more than 1½ bales per acre are open. Therefore, any difference in fineness due to maturity is small and of no consequence. The range in fineness among harvesting methods for any particular year was very small and followed no particular pattern (appendix table 11). The 3-year averages, although slightly favoring the straight spindles, indicate that no real differences exist among the four methods of harvesting.

MANUFACTURING WASTE

One measure of the harvesting process is the amount of picker and card waste removed in textile processing of cotton harvested by the different harvesting methods. However, this measurement does not provide an accurate indication of the type of trash that might be embedded in the fiber.

For each of the 3 years and the seasonal averages, hand-picked cotton produced significantly less picker and card waste than cotton harvested with any of the three types of spindles (appendix table 12). There was no difference in trash due to type of spindles except in 1963. The 3-year averages were no different for spindle types.

Foreign matter in hand-picked cotton normally is larger in particle size and more easily removed in mill processing than that contained in machine-harvested cotton. Pin trash embedded in fibers, since it is small in size and difficult to remove, can be a source of end breakage during the spinning process. There is a direct correlation between the amount of manufacturing waste removed and end breakage, both among types of harvesting and among the three types of spindles studied. However, crusher rolls in mills, introduced since this study was completed, can largely eliminate pin trash as a source of yarn breakage. These devices pulverize small foreign particles and make them ineffective as a source of trouble. Since there were no significant differences in fiber properties among harvesting methods, it would be expected that there would be no differences in spinning performance if trash as a source of trouble were eliminated.

PROCESSING PERFORMANCE

There are many possible criteria for the evaluation of processing performance of cotton. The more important of these are yarn breakage during spinning (ends-down) and such yarn-quality factors as yarn strength, appearance, neppiness, and yarn irregularity. Manufacturing waste, long considered a measure of processing performance, is now more of an extraneous weight factor after the introduction of crusher rolls in textile mills, but it is still a measure of harvesting efficiency. Cotton samples in this test were processed without using crusher rolls.

Yarn breakage in spinning

Yarn breakage during the spinning process can be a source of quality deterioration, and it has a significant effect on manufacturing costs. It can be caused by many quality deficiencies, among which are decreased staple length, altered length distribution, and the presence of small particles of foreign matter that are embedded in the fibers and that are difficult to remove.

Except for the 1961 tests, there were differences in spinning performance as measured by ends-down per thousand spindle hours (appendix table 13). Generally, there was a tendency for hand-picked cotton to spin better than machine-harvested cotton. Based on the 3-year averages and a 10-percent significance level, the cotton harvested with barbed spindles spun worse than that harvested with the straight smooth spindle. At the 5-percent level, only the cotton harvested with the tapered barbed spindle spun worse than that harvested with the straight smooth spindle. At the 1-percent level, differences among types of spindles were not significant, but the differences ranged from 57 to 72 ends-down per thousand spindle hours. Hand-picked cotton had an ends-down level of 44.

Neps in card web

There were no significant differences in neps per 100 square inches of card web among lots of cotton harvested with the different types of spindles (appendix table 14). The mean average for hand-picked cotton, although lowest and of significance at the 10-percent level, does not appear to be of major importance as a quality difference. The level of neps was rather low for all harvesting methods with a maximum difference of one nep.

Yarn quality

Yarn quality in this study was measured in terms of strength of yarn, yarn-appearance index, neps per thousand yards of yarn, and irregularity coefficient of variation.

Yarn-strength differences among harvesting methods were small—the maximum difference in any year being 67 break-factor units and even less for the 3-year averages (appendix table 15). Generally, hand-picked cotton had a lower break factor, but the difference in yarn strength for any of the three types of spindles was small and of little consequence in the yearly and 3-year averages. There was no significant difference in yarn strength for the different types of spindles at the 5-percent significance level.

Yarn-appearance index showed no significant difference for any type of harvesting (appendix table 16). Uster yarn irregularity was also similar for all harvesting methods (appendix table 17).

Neppiness of the yarn produced was slightly higher (10-percent level of significance) for cotton harvested with the two types of barbed spindles than that harvested with the smooth spindle or by hand (appendix table 18). At the 5-percent level, cotton harvested with the tapered barbed spindle had more neps in the yarn than did hand-picked cotton.

It is significant that cotton harvested with the two types of barbed spindles also had more manufacturing waste and ends-down than cotton picked by hand or by a machine harvester with smooth spindles.

APPENDIX

TABLE 1.—*Adjustments of moistening agent and speed for cotton harvesters, California, 1961–63*

Item	Machine with—		
	Barbed tapered spindles	Square straight spindles	Barbed straight spindles
Rate of moistening agent:			
1961	(1)	(1)	(1)
1962 gal./acre	3.16	3.75	4.72
1963 gal./acre	5.39	4.03	8.27
Concentration of detergent	1/200	1/200	1/200
Harvesting speed m.p.h.	2.10	3.30	3.30

[1] Not measured.

TABLE 2.—*Field conditions at time of cotton harvest*

Item	1961	1962	1963
Plant population plants/acre	66,000	39,700	29,160
Plant height inches	40.2	38.1	43.3
Height of 1st fruit node do	8.8	6.1	5.0
Green bolls number/acre	(1)	19,700	21,600
Seed cotton yield lb./acre	2,390	3,062	3,754
Relative humidity percent	40	35	70

[1] Not measured.

TABLE 3.—*Percentage of foreign matter and moisture content of cotton harvested by 4 methods, California, 1961–63*

Measurement and year	Hand-picked	Machine-picked with indicated type of spindle		
		$\frac{9}{16}$ in. tapered barbed	$\frac{3}{16}$ in. straight smooth	¼ in. straight barbed
Seed cotton, on trailer:				
Foreign matter:				
1961	6.5	6.6	6.5	6.4
1962	6.9	5.7	6.8	7.2
1963	4.8*	6.6	6.5	6.6
Moisture:				
1961	5.6*	7.1	7.0	7.1
1962	5.0*	6.4	7.1	7.6
1963	13.7	12.9	14.2	14.2
Lint moisture:				
On trailer:				
1961	3.8*	5.6	5.4	5.8
1962	4.2*	5.4	5.8	6.8
1963	10.2	10.4	11.2	11.4
At lint-slide:				
1961	4.0	4.3	4.3	4.3
1962	4.2	4.4	4.2	4.4
1963	5.6	5.8	5.8	5.8

* Value for the harvesting methods significantly different at the 5-percent level of significance for the individual year.

TABLE 4.—*Grade and staple of ginned lint of cotton harvested by 4 methods, California, 1961–63*

Grade or staple and season	Hand-picked	Machine-picked with indicated type of spindle		
		$\frac{9}{16}$ in. tapered barbed	$\frac{3}{16}$ in. straight smooth	¼ in. straight barbed
Grade:[1]	*Index*	*Index*	*Index*	*Index*
1961	102	98	100	98
1962	104	101	100	99
1963	100	94	94	94
Average	101.8	97.2	97.6	96.7
Staple:	*32d in.*	*32d in.*	*32d in.*	*32d in.*
1961	34.0	35.0	35.0	35.0
1962	35.0	35.0	35.3	35.7
1963	34.2	34.8	34.6	35.0
Average	34.5	34.8	34.8	35.2

[1] Grade index: 94, strict low middling; 100, middling; 104, strict middling.

TABLE 5.—*Upper quartile length, in inches, of ginned lint of cotton harvested by 4 methods, California, 1961–63*

[Length measured by the array method]

Season	Hand-picked	Machine-picked with indicated type of spindle		
		$\frac{9}{16}$ in. tapered barbed	$\frac{3}{16}$ in. straight smooth	¼ in. straight barbed
1961[1]	1.207	1.210	1.210	1.203
1962[1]	1.260	1.250	1.250	1.250
1963[1]	1.210	1.210	1.212	1.212
Average[1]	1.224	1.223	1.223	1.221

[1] No significant differences among harvesting methods according to Duncan's multiple range test at the 10-percent level of significance.

TABLE 6.—*Mean length, in inches, of ginned lint of cotton harvested by 4 methods in California, 1961–63*

[Length by the array method. Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	0.997	1.016	1.016	1.003	(2)(3) > (1)(4)
1962	1.040	1.040	1.030	1.040	NS
1963	1.002	1.002	1.008	1.010	NS
Average	1.011	1.018	1.017	1.017	See data below

Duncan's multiple range test applied to 3-year average:[2]	(1)	(3)	(4)	(2)
10-percent level	1.011	1.017	1.017	1.018
5-percent level	1.011	1.017	1.017	1.018

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

TABLE 7.—*Coefficient of variation, percent, in fiber length of cotton harvested by 4 methods, California, 1961–63*

[Length measured by the array method. Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	29.7	28.3	28.3	29.0	(1) > (2)(3)
1962	30.0	29.3	30.0	28.7	(1)(3) > (4)
1963	28.5	29.2	28.5	28.5	NS
Average[2]	29.3	29.0	28.9	28.7	

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] No significant differences among harvesting methods according to Duncan's multiple range test at the 10-percent level of significance.

TABLE 8.—*Percentage of fibers shorter than ½ inch in lint of cotton harvested by 4 methods, California, 1961–63*

[Length measured by the array method]

Season	Hand-picked	Machine-picked with indicated type of spindle		
		9/16 in. tapered barbed	3/16 in. straight smooth	¼ in. straight barbed
1961[1]	8.4	7.3	7.6	8.2
1962[1]	8.4	8.4	8.7	7.9
1963[1]	8.0	8.6	8.1	8.1
Average[1]	8.3	8.2	8.1	8.1

[1] No significant differences among harvesting methods according to Duncan's multiple range test at the 10-percent level of significance.

TABLE 9.—*Percentage of fibers longer than 1 inch in lint of cotton harvested by 4 methods, California, 1961–63*

[Length by the array method. Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle			Significant treatment differences[1]
		9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	¼ in. straight barbed (4)	
1961	61.4	64.7	63.7	61.7	(2)(3) > (1)(4)
1962	66.7	67.6	66.9	68.1	NS
1963	62.8	63.0	62.9	63.1	NS
Average	63.5	64.9	64.3	64.2	See data below

Duncan's multiple range test applied to 3-year average:[2]				
10-percent level	(1) 63.5	(4) 64.2	(3) 64.3	(2) 64.9
5-percent level	63.5	64.2	64.3	64.9

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

TABLE 10.—*Fiber strength of ginned lint of cotton harvested by 4 methods, California, 1961–63*

[Numbers in parentheses refer to harvesting methods]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
Zero gage:	*1,000 p.s.i.*	*1,000 p.s.i.*	*1,000 p.s.i.*	*1,000 p.s.i.*	
1961	92.3	93.0	94.0	93.3	NS
1962	84.0	86.3	90.3	85.0	(3) > (1)(2)(4)
1963	95.8	97.5	95.0	94.2	NS
Average	91.2	92.8	93.3	91.2	See data below
1/8-in. gage:	*Grams tex*	*Grams tex*	*Grams tex*	*Grams tex*	
1961	26.3	26.6	27.3	26.6	(3) > (1)(2)(4)
1962	24.0	25.0	25.0	23.9	NS
1963	25.6	25.8	25.3	25.4	NS
Average	25.3	25.8	25.8	25.3	See data below

Duncan's multiple range test applied to 3-year average:[2]	(4)	(1)	(2)	(3)	
Zero gage:	*1,000 p.s.i.*	*1,000 p.s.i.*	*1,000 p.s.i.*	*1,000 p.s.i.*	
10-percent level	91.2	91.2	92.8	93.3	
5-percent level	91.2	91.2	92.8	93.3	
1/8-in. gage:	*Grams tex*	*Grams tex*	*Grams tex*	*Grams tex*	
10-percent level	25.3	25.3	25.8	25.8	
5-percent level	25.3	25.3	25.8	25.8	

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

TABLE 11.—*Fiber fineness, ug./in., of ginned lint of cotton harvested by 4 methods, California, 1961–63*

[Fineness measured by micronaire. Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	4.6	4.6	4.4	4.4	(1)(2) > (3)(4)
1962	4.4	4.5	4.4	4.3	(2) > (4)
1963	4.8	4.8	4.8	4.8	NS
Average	4.60	4.63	4.57	4.54	See data below

Duncan's multiple range test applied to 3-year average:[2]	(4)	(3)	(1)	(2)
10-percent level	4.54	4.57	4.60	4.63
5-percent level	4.54	4.57	4.60	4.63
1-percent level	4.54	4.57	4.60	4.63

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

TABLE 12.—*Percentage of picker and card waste in lint of cotton harvested by 4 methods, California, 1961–63*

[Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	4.84	5.16	5.18	5.24	(2)(3)(4) > (1)
1962	3.45	3.76	3.71	3.69	(2)(3)(4) > (1)
1963	3.08	3.38	3.33	3.43	(2)(3)(4) > (1)
					(4) > (3)
Average	3.72	4.03	4.00	4.05	See data below

Duncan's multiple range test applied to 3-year average:[2]	(1)	(3)	(2)	(4)
10-percent level	3.72	4.00	4.03	4.05
5-percent level	3.72	4.00	4.03	4.05
1-percent level	3.72	4.00	4.03	4.05

[1] Based on Duncan's multiple range test at the 10-percent level of significance.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

TABLE 13.—*Yarn breakage during spinning (corrected ends-down, number per thousand spindle hours, for 40's yarn) from cotton harvested by 4 methods, California, 1961–63*

[Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	48.3	54.7	44.7	50.7	NS
1962	32.7	58.3	41.7	43.3	(2) > (1)(3)(4) (3)(4) > (1)
1963	50.2	94.0	78.5	100.00	(2)(4) > (1)(3) (3) > (1)
Average	44.4	71.5	57.3	68.2	See data below

Duncan's multiple range test applied to 3-year average:[2]	(1)	(3)	(4)	(2)
10-percent level	44.4	57.3	68.2	71.5
5-percent level[3]	44.4	57.3	68.2	71.5
1-percent level	44.4	57.3	68.2	71.5

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

[3] F ratio for treatment × years interaction is significant at this level.

TABLE 14.—*Number of neps per hundred square inches of card web in lint of cotton harvested by 4 methods, California, 1961–63*

[Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	20	21	20	21	NS
1962	11	12	12	12	NS
1963	12	12	13	13	NS
Average	14.3	14.8	14.7	15.1	See data below

Duncan's multiple range test applied to 3-year average:[2]	(1)	(3)	(2)	(4)
10-percent level	14.3	14.7	14.8	15.1
5-percent level	14.3	14.7	14.8	15.1

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

TABLE 15.—*Break factor, units, of yarn spun from cotton harvested by 4 methods, California, 1961–63*

[Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	2245	2297	2296	2263	(2)(3) > (4) > (1)
1962	2200	2267	2253	2227	(2)(3)(4) > (1)
1963	2273	2293	2300	2293	NS
Average	2243	2286	2285	2264	See data below

Duncan's multiple range test applied to 3-year average:[2]	(1)	(4)	(3)	(2)
10-percent level	2243	2264	2285	2286
5-percent level	2243	2264	2285	2286
1-percent level	2243	2264	2285	2286

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

TABLE 16.—*Appearance index of yarn from cotton harvested by 4 methods, California, 1961–63*

[Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle: 9/16 in. tapered barbed (2)	3/16 in. straight smooth (3)	1/4 in. straight barbed (4)	Significant treatment differences[1]
1961	93.3	93.3	96.7	100.0	NS
1962	100.0	103.3	100.0	103.0	NS
1963	114.8	112.5	113.8	111.8	(1) > (4)
Average[2]	103.9	104.0	104.5	105.7	----------

[1] Based on Duncan's multiple range test at the 10-percent level of significance. NS, not significant.

[2] No significant differences among harvesting methods according to Duncan's multiple range test at the 10-percent level of significance.

TABLE 17.—*Yarn irregularity coefficient of variation, percent, of 40's yarn spun from cotton harvested by 4 methods, California, 1962–63*

Season	Hand-picked	Machine-picked with indicated type of spindle		
		$\frac{9}{16}$ in. tapered barbed	$\frac{3}{16}$ in. straight smooth	¼ in. straight barbed
1962[1]	22.9	23.4	22.9	23.3
1963[1]	20.8	20.7	20.8	20.6
Average[1]	21.70	20.84	21.71	21.80

[1] No significant difference among harvesting methods according to Duncan's multiple range test at the 10-percent level.

TABLE 18.—*Number of neps per thousand of 40's yarn spun from cotton harvested by 4 methods, California, 1962–63*

[Numbers in parentheses refer to harvesting method]

Season	Hand-picked (1)	Machine-picked with indicated type of spindle			Significant treatment differences[1]
		$\frac{9}{16}$ in. tapered barbed (2)	$\frac{3}{16}$ in. straight smooth (3)	¼ in. straight barbed (4)	
1962	958	1,106	968	1,025	(2) > (1)(3)
1963	405	451	412	454	(2)(4) > (1)(3)
Average	642	732	650	699	See data below

Duncan's multiple range test applied to 3-year average:[2]				
10-percent level	(1) 642	(3) 650	(4) 699	(2) 732
5-percent level	642	650	699	732

[1] Based on Duncan's multiple range test at the 10-percent level of significance.

[2] Values not underscored by the same solid line are different at the indicated levels of significance.

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